

# Runoff, erosion, and soil quality characteristics of a former Conservation Reserve Program site

J.E. Gilley, J.W. Doran, D.L. Karlen, and T.C. Kaspar

**ABSTRACT:** No-till and moldboard plow tillage systems were established on a former Conservation Reserve Program (CRP) site in southwest Iowa. Runoff rates from simulated rainfall events were significantly greater on sites returned to crop production than from adjoining, undisturbed CRP areas. Substantial soil loss was measured from the moldboard plow treatments, but no significant differences in erosion rates were found between the undisturbed CRP and no-till management systems. No-till management maintained levels of soil quality similar to those of CRP by preserving soil structural integrity and reducing losses of soil organic matter (SOM) associated with tillage. Conservation tillage systems which maintain residue materials on the soil surface may be well suited for former CRP areas which are used as cropland.

The CRP was initiated to remove environmentally fragile areas from crop production. Approximately 14.8 million hectares (36.5 million acres) of cropland, primarily west of the Mississippi, were enrolled in this program. To participate in the CRP, producers were required to convert cropland to vegetative cover for a 10-year period. In addition to reducing soil erosion, the CRP has served to decrease crop production, improve soil and water quality, and create better wildlife habitat. Gebhart et al. (1994) found that establishment of perennial grass cover under the CRP resulted in significant increases in soil organic carbon at five selected locations within the Great Plains.

When CRP contracts expire, some producers may return their land to crop production, destroying well-established grass cover. Because the CRP was targeted to many highly erodible soils, returning these areas to crop production could have detrimental effects on water quality and long-term soil productivity (Young and Osborn 1990). The residual benefit of the CRP in

reducing erosion was found to be eliminated nine months following tillage when herbicides were used to prevent the regrowth of vegetation on a site in Northern Mississippi (Gilley and Doran 1997). Appropriate conservation management measures will, therefore, be needed on many former CRP areas. Lindstrom et al. (1994) suggested use of no-till management systems to preserve soil quality improvements on former CRP lands and to provide effective erosion protection. Detailed information on the effects of grass sod on soil properties and crop productivity at Big Spring, Texas was provided by Zobeck et al. (1995).

Management systems that include sod have many environmental and production advantages. In the Southeastern United States, sod crops planted in sequence with row crops have been found to increase crop yields, provide more efficient use of water and fertilizer, and reduce runoff and erosion (Bennet et al. 1976; Carreker et al. 1977; Harper et al. 1980; Belesky et al. 1981; and Wilkinson et al. 1987). No-till corn planted in sod produces excellent yields when nutrient and water requirements are met (Moody et al. 1963; Jones

et al. 1969; Carreker et al. 1973; Box et al. 1976, 1980). Corn yields are greatest the first year after sod, and then decline with each succeeding year of corn production (Parks et al. 1969; Giddens et al. 1971). Elkins et al. (1979, 1983) concluded that acceptable corn yields could be obtained while maintaining a living grass mulch. Herbicide application rates, vigor of the grass stand, and climatic factors all contribute to the success of intercropping management systems.

Soybeans may be the crop of choice during the first growing season following CRP conversion to cropland, as they may be less susceptible to stand establishment problems caused by insects and animals. Available soil N, which is immobilized in SOM with perennial grasses, can be partially replenished through N fixation by soybeans which add readily mineralizable, N rich residues to soil. Many contact postemergence herbicides, that work well when large amounts of surface residue or SOM are present, are available for soybean production.

A field recently plowed out of meadow is initially much less erodible than one which has been continuously tilled. The fine root network and improved soil structure from meadows serve to maintain high infiltration rates and protect the soil against erosive forces (Foster 1982). In general, the erosion-reducing effectiveness of sod is directly proportional to vegetative dry matter production (Wischmeier and Smith 1978). The objective of this study was to measure the effects of no-till and moldboard plow tillage practices on runoff, erosion, and soil quality of a site in southwestern Iowa the first cropping season after CRP.

## Procedures

The study site was located approximately 16 km (10 miles) east of Bedford, Iowa. Prior to 1986, the area had been planted primarily to corn and soybeans. The site had been idled in the CRP since October 1986 and is part of a no-till re-

*J.E. Gilley is an agricultural engineer and J.W. Doran is a soil scientist with USDA-ARS located at the University of Nebraska, Lincoln, 68583. D.L. Karlen is a soil scientist and T.C. Kaspar is a plant physiologist with USDA-ARS located at the National Soil Tilth Laboratory, Ames, IA 50011. This article is a contribution from USDA-ARS in cooperation with the Agricultural Research Division, University of Nebraska, Lincoln, and is published as Journal Series No. 11143.*

*The authors wish to express their sincere appreciation to David Danielski, David Dukes, and Richard Fee for their cooperation and assistance in conducting this study. It would not have been possible to have completed this investigation without the dedicated efforts of these individuals.*

*J. Soil and Water Cons. 52(3) 189-193*

## Interpretive summary

No-till and moldboard plow tillage systems were established on a former Conservation Reserve Program site in southwest Iowa. Runoff rates from simulated rainfall events were significantly greater on sites returned to crop production than from adjoining undisturbed CRP areas. Substantial soil loss was measured from the moldboard plow treatments, but no significant differences in erosion rates were found between the undisturbed CRP and no-till management systems. No-till management maintained levels of soil quality similar to those of CRP by preserving soil structural integrity and reducing losses of soil organic matter associated with tillage. Conservation tillage systems which maintain residue materials on the soil surface may be well suited for former CRP areas which are used as cropland.

**Key words:** conservation, erosion, land management, runoff, soil conservation, soil quality, tillage.

**Table 1. Slope, surface cover, and vegetative mass for selected experimental treatments**

Soil	Treatment	Slope	Surface cover*	Vegetative mass†
		(%)	(%)	(Mg/ha‡)
Clearfield	CRP undisturbed	8.4	100a	07.6c
Clearfield	No-till corn	4.7	100a	02.7b
Clearfield	No-till soybeans	5.0	100a	05.1d
Clearfield	Fall plow soybeans	4.4	78b	01.6e
Nira	CRP undisturbed	3.9	100a	09.0c
Nira	No-till corn	6.0	100a	20.5a
Nira	No-till soybeans	8.2	100a	04.6d
Nira	Spring plow soybeans	6.5	78b	01.6e
Nira	Fall plow soybeans	7.7	64c	01.1e

\* Values given are the average of six replications. Within each column, differences are significant at the 5% level (Duncan's multiple range test) if the same letter does not appear.

† Values given are the average of two replications.

‡ Mg/ha × 0.446 = tons/acre

**Table 2. Runoff, sediment concentration, and soil loss for selected experimental treatments\***

Soil	Treatment	Run	Runoff†	Sediment Conc.	Soil Loss
			(mm)	(ppm × 10 <sup>3</sup> )	(t/ha)
Clearfield	CRP undisturbed	Initial	24de	0.2c	0.0b
Clearfield	No-till corn	Initial	34cd	0.8c	0.2b
Clearfield	No-till soybeans	Initial	64ab	0.4c	0.2b
Clearfield	Fall plow soybeans	Initial	51bc	19.0ab	10.0a
Nira	CRP undisturbed	Initial	10e	1.3c	0.1b
Nira	No-till corn	Initial	86a	1.2c	0.8b
Nira	No-till soybeans	Initial	83a	0.6c	0.3b
Nira	Spring plow soybeans	Initial	73ab	11.8bc	8.5a
Nira	Fall plow soybeans	Initial	53bc	25.4a	14.4a
Clearfield	CRP undisturbed	Wet	29b	0.1b	0.0b
Clearfield	No-till corn	Wet	54b	0.6b	0.2b
Clearfield	No-till soybeans	Wet	89a	0.3b	0.2b
Clearfield	Fall plow soybeans	Wet	81a	11.8a	8.9a
Nira	CRP undisturbed	Wet	32b	0.4b	0.1b
Nira	No-till corn	Wet	81a	0.6b	0.4b
Nira	No-till soybeans	Wet	99a	0.3b	0.2b
Nira	Spring plow soybeans	Wet	87a	11.4a	9.5a
Nira	Fall plow soybeans	Wet	86a	18.8a	16.2a

\* Plots were 3.0 by 10.7 m with an average slope gradient of 6.1%. Values given are the average of two replications. Runs lasted for a 60-min duration. Average rainfall intensity was 95 mm/hr.

† Within each type of run and for each column, differences are significant at the 5% level (Duncan's multiple range test) if the same letter does not appear.

search and demonstration project on the David Danielski farm. Vegetative cover on the CRP site consisted of approximately 60% bromegrass (*Bromus inermis*), 25% orchardgrass (*Dactylis glomerata*), 10% weeds, and 5% legumes. Climate for this area is humid continental, with a high frequency of yearly spring and summer thunderstorms. The frequency for a 5.3 cm (2.1 in) rainfall of one-hour duration is every 5 years, and for a 9.1 cm (3.6 in) storm is every 100 years. Mean annual temperature is 9.7°C (49°F) and mean annual precipitation is 90 cm (36 in), 71% of which occurs from April through September.

Both Clearfield (Fine, montmorillonitic, mesic Typic Haplaquolls) and Nira (Fine-silty, mixed, mesic Typic Hap-

ludolls) silty clay loam soils were present at the study site on 5 to 9 percent slopes. These soils were formed in deoxidized loess on convex side slopes on upland landscape positions. The Clearfield series consists of poorly drained, moderately slowly permeable soils, while Nira soils located downslope from soils in the Clearfield series are moderately well drained and moderately permeable. The uneroded A horizon of both soils typically extends from 25 to 40 cm (10-16 in), but is thinner on eroded areas.

Five treatments which included CRP undisturbed, no-till corn (*Zea mays* L.) no-till soybeans (*Glycine max* (L.) Merr.), spring moldboard plow soybeans and fall moldboard plow soybeans, were placed on each soil by David Dukes, a no-till farmer

and co-sponsor of the CRP project. Both plow treatments were disked two times before planting. The cover of soybeans on the Clearfield spring moldboard plow treatment was disturbed during simulation testing on an adjoining area. As a result, rainfall simulation tests were not conducted at this site. However, soil quality characteristics were identified on an area of this treatment which was not disturbed.

Vegetation existing on the experimental site was not mowed in 1993 or 1994. Herbicide was applied a few days after a killing frost to the no-till corn treatment on October 4, 1993. The no-till corn treatment was seeded on April 27, 1994, and had to be replanted on May 19, 1994, as the young plants were destroyed by mice and pheasants. The no-till soybean plots received a single application of herbicide on May 8, 1994. On May 12, 1994, the treatments planted to soybeans were seeded using a drill. The no-till type drill worked well under the existing high residue conditions.

Two rainfall simulation plots with 3.0 m (9.8 ft) wide by 10.7 m (35.1 ft) long sheet metal borders were established on uniform slopes for each of the experimental treatments (Table 1). A portable rainfall simulator designed by Swanson (1965) was used from June 14, 1994, to July 8, 1994, to apply rainfall at an approximate intensity of 9.5 cm/h (3.7 in/h). The initial one hour rainfall application occurred at existing soil-water conditions. A second one-hour application (wet run) was conducted approximately 24 h later. A trough extending across the bottom of each plot gathered runoff. Discharge was measured using an HS flume with stage recorder. Runoff samples were collected at 5-min intervals in a trough located at the bottom of each plot and later analyzed for sediment content.

Colored slides were taken at three locations on each plot prior to the simulation tests and later projected onto a screen containing a grid. The number of residue and crop elements intersecting the grid points was then determined (Mannering and Meyer 1963). The ratio of the number of intersection points over the total grid points times 100 is the percentage of the soil surface covered by residue.

The amount of vegetative material present on the soil surface greatly influences runoff and erosion (Gilley et al. 1986, 1987). Therefore, duplicate samples of vegetative dry matter were collected within a 0.589 m<sup>2</sup> (6.34 ft<sup>2</sup>) circular area. Standing vegetative materials and residue lying on the soil surface within the frame

**Table 3. Tillage and cropping effects on selected soil quality indicators for the 0 - 7.6 cm depth of the Clearfield silty clay loam soil**

Soil quality indicator	Treatment			
	CRP undisturbed	No-till corn	Spring plow soybeans	Fall plow soybeans
Wet bulk density (g/cm <sup>3</sup> )	1.21 (0.04)*	1.12 (0.06)	1.18 (0.02)	1.14 (0.01)
Water-holding capacity <sup>†</sup> (g H <sub>2</sub> O/g soil)	0.25 (0)	0.30 (0)	0.41 (0.10)	0.34 (0.03)
Infiltration time (minutes) first 2.5 cm H <sub>2</sub> O	0.3 (0.15)	0.4 (0.3)	0.1 (0.07)	0.2 (0.07)
second 2.5 cm H <sub>2</sub> O	16 <sup>‡</sup> (9)	4 (1)	28 (21)	31 (5)
Soil pH (1:1 soil/water)	7.5 (0.1)	7.1 (0.2)	6.5 (0.2)	6.5 (0.2)
Electrical conductivity (1:1 soil/water, dS/m)	0.06 (0.01)	0.08 (0.03)	0.09 (0.02)	0.20 (0.04)
Nitrate-N (kg/ha)	0.6 (0.2)	3.5 (1.6)	11.5 (1.7)	17.5 (7.7)
Total C Mg/ha	27.8 (0.3)	23.2 (3.0)	15.9 (0.5)	15.2 (1.3)
Total N Mg/ha	2.1 (0.06)	1.6 (0.3)	1.3 (0.04)	1.3 (0.13)
Very fine silt & clay (%)	26 (2)	25 (13)	31 (7)	30 (5)
Soil Respiration, (kg C/ha/day), 25°C				
Before irrigation % WFPS	56(24) 44 <sup>§</sup>	19(6) 45	12(3) 30	20(13) 33
After irrigation % WFPS	48(4) 56	84(8) 60	7(7) 88	34(22) 69

\* Value in parenthesis represents standard deviation of the mean.

<sup>†</sup> Measured in the field 16 hours after application of 5.1 cm of water.

<sup>‡</sup> Infiltration time for second 2.5 cm of water.

<sup>§</sup> % soil pore space filled with water for respiration measurement.

were removed immediately prior to the rainfall simulation tests and stored in paper bags. The material was later oven dried, and the weight of dry matter per unit area was calculated. Duncan's multiple range test was used to identify statistical differences in vegetative mass between experimental treatments.

Basic indicators of soil quality as described by Doran and Parkin (1994) were used to evaluate four management treatments. Soil quality assessments for the 0-7.6 cm (0-3.0 in) depth were conducted in the field for 3 replicated sites on May 23 and 24, 1994, before rainfall simulation tests were initiated. On-site soil quality measurements as described by Sarrantonio et al. (1996) included wet bulk density, water holding capacity, infiltration time, soil pH, electrical conductivity, nitrate-N, and soil respiration before and after irrigation with two 2.54 cm (1.00

in) increments of water.

Fifteen cm (6.0 in) diameter aluminum rings, installed in the soil to a 7.6 cm (3.0 in) depth, were used for infiltration and respiration measurements. The soil infiltration rate determined after the addition of the second 2.54 cm (1.00 in) of water represented a 'ponded' infiltration rate. The soil water content 16 hours after irrigation was used as an estimate of field water holding capacity. Further details on the utility and reliability of these approaches for measuring soil water status are given by Lowery et al. (1996).

Soil samples from depth intervals of 0-7.6 cm (0-3.0 in), 7.6-15.2 cm (3.0-6.0 in), and 15.2-30.5 cm (6.0-12.0 in) were taken for characterization and laboratory assessments of soil quality by compositing 12 randomly sampled 1.9 cm (0.75 in) diameter cores from each treatment. Samples were stored under ice in an insulated

chest and processed within 48 hours. Moist soil samples were passed through a 0.475 cm (0.187 in) sieve before analyses for microbial biomass C and N by the chloroform fumigation/incubation procedure, and mineralizable N by the anaerobic incubation method. Samples which passed through a 0.2 cm (0.08 in) sieve were analyzed for 1N KCL extractable mineral N (NO<sub>3</sub> and NH<sub>4</sub>), total C and N by dry combustion, Bray-1 extractable P, and particle size analysis by the hydrometer method. The methods used for laboratory analyses were all standard procedures employed by the USDA-ARS Soil and Water Conservation Research Unit, Lincoln, Nebraska, and the University of Nebraska Soil and Plant Testing Laboratory. Gravimetric data were converted to a volumetric basis using field measured soil bulk density which enabled conversion of data to ecologically relevant units which are needed for meaningful soil quality evaluations (Doran and Parkin 1996).

## Results and discussion

**Surface cover.** Vegetative material lying on the ground surface and standing corn or soybean plants were all included in the surface cover values shown in Table 1. Vegetative material completely covered the ground surface on the CRP undisturbed and no-till corn and soybean treatments. No-till surface cover consisted primarily of residual grass residue accumulated during the CRP period. In contrast, as expected, very little residual grass cover was present on either the fall or spring moldboard plow treatments. Surface cover on the fall and spring moldboard plow treatments was provided primarily by the recently seeded soybean crop (Table 1). As a result, surface cover values were significantly less on these plots than on the other experimental treatments.

**Vegetative mass.** Measurements of vegetative mass (Table 1) included recently planted corn or soybean material in addition to plant residue accumulated during the CRP period. However, most of the vegetative material produced during the CRP period was incorporated into the soil profile during the moldboard plowing operation. Therefore, vegetative mass on the moldboard plow treatments consisted almost entirely of soybean material from the current cropping season. Vegetative mass on the moldboard plow treatments was significantly less than for any of the other experimental treatments. On the no-till soybean treatments, a substantial quantity of residual grass residue remained on the soil surface. However, the amount of vegetative material present on

**Table 4. Tillage and cropping effects on selected soil quality indicators for the 0 - 7.6 and 0 - 30.5 cm depth of the Clearfield silty clay loam soil**

Soil quality indicator	Depth (cm)	Treatment			
		CRP undisturbed	No-till corn	Spring plow soybeans	Fall plow soybeans
Dry bulk density (g/cm <sup>3</sup> )	0-7.6	1.03	1.20	0.86	0.83
	0-30.5	1.05	1.17	1.02	1.11
Soil pH (1:1 soil/water)	0-7.6	6.9	6.6	6.3	6.4
	0-30.5	6.8	6.4	6.4	6.6
Nitrate-N (kg/ha)	0-7.6	0.6	7.4	10.6	13.7
	0-30.5	1.1	18.3	31.0	47.1
Total C (Mg/ha)	0-7.6	24.5	22.3	12.1	11.6
	0-30.5	80.2	70.1	59.3	60.9
Total N (Mg/ha)	0-7.6	1.7	1.9	1.0	0.9
	0-30.5	5.7	5.3	4.7	4.9
Microbial C (kg/ha)	0-7.6	289	205	188	152
	0-30.5	939	791	724	825
Microbial N (kg/ha)	0-7.6	48	35	17	15
	0-30.5	104	80	106	68
Mineralizable N (kg/ha)	0-7.6	57	49	11	18
	0-30.5	83	75	73	96
Extractable P (kg/ha)	0-7.6	54	46	19	20
	0-30.5	98	64	58	71
Very fine silt & clay (%)	0-7.6	32	28	31	33
	0-30.5	30	32	36	37

**Table 5. Tillage and cropping effects on soil organic matter, infiltration, runoff, soil loss, and grain yield for the Clearfield silty clay loam soil**

Treatment	Soil organic matter		Infiltration*		Rainfall simulation†		Grain Yield (Mg/ha)
	Total C [Mg/ha (0-30.5 cm)]	Total N [Mg/ha (0-30.5 cm)]	1st (minutes)	2nd (minutes)	Runoff (mm)	Soil Loss (t/ha)	
CRP undisturbed	80.2	5.7	0.3	16	10	0.0	—
No-till corn	70.1	5.3	0.4	4	9	0.1	10.9
Spring plow soybeans	59.3	4.7	0.1	28	35‡	3.1‡	3.7
Fall plow soybeans	60.9	4.9	0.2	31	20	4.1	3.9

\* Time for 1st- and 2nd- 2.54 cm of water to infiltrate the soil.

† Runoff and soil loss during the 1st 1/2 hour of the initial run at a rainfall intensity of 95 mm/hr.

‡ Rainfall simulation measurements from the spring plow treatment on the Nira silty clay loam soil.

the no-till soybean treatments was significantly less than that on the undisturbed CRP treatments. Decomposition of the residual grass residue and residue buried by the soybean drill could account for the difference. Significantly larger amounts of vegetative material were found on the no-till corn treatments than the other experimental plots. Although some residual grass residue was present at the time of the simulation tests, most of the vegetative mass was provided by the current corn crop.

**Runoff.** Cumulative runoff for both the initial and wet runs on each treatment are shown in Table 2. Average rainfall intensity was 9.5 cm/hr (3.7 in/hr) for all the simulation runs. Variations from this av-

erage value sometimes occurred primarily because of differences in water pressure and wind drift. Cumulative runoff was greater than the average rainfall intensity for the wet run on the Nira no-till soybean treatment. For this run, a rainfall intensity slightly larger than the average for the nine experimental treatments was applied and little infiltration occurred. Variations in antecedent soil water conditions between experimental treatments would be expected to have less effect on runoff results obtained during the wet run. Therefore, to evaluate runoff trends, results from the wet runs were examined. Surface soils in each treatment were nearly saturated at the beginning of the wet run.

Total runoff from the wet run on the

CRP undisturbed plots was significantly less than that for the other treatments (Table 2). These simulation results indicate that infiltration was significantly reduced on Clearfield and Nira soils that were returned to crop production. Reductions in infiltration during the first cropping season were similar for the no-till and moldboard plow treatments.

**Soil loss.** Sediment concentration and soil loss are also presented in Table 2. The moldboard plow treatments provided the largest soil loss and highest sediment concentrations (Table 2). In contrast, no significant difference in soil loss was found between the CRP undisturbed and no-till treatments. Sufficient surface cover was present on the no-till treatments to prevent significant erosion.

The residual grass cover from the CRP appears to provide an important benefit during the initial cropping season. However, this residue soon disappears due to decomposition. Planted crops must provide a sufficient amount of ground cover to replace the residual grass cover. In addition, a management system must be selected which adequately maintains ground cover. A no-till system seems to be well suited to provide this benefit.

#### **Cropping/tillage effects on soil quality.**

Cropping of CRP land and tillage management greatly influenced the quality of surface soil (0-7.6 cm) (0-3.0 in), largely through changes in SOM content (total C and N), infiltration characteristics, water holding capacity, and soil nitrate-N contents (Table 3). Bulk density and pH were similar for all treatments and within ranges considered acceptable for sustainable management. Total C and N of surface soil were substantially decreased on the tillage treatments when compared to undisturbed CRP. These dramatic changes in SOM content, in addition to the disruptions in soil structure associated with moldboard plowing, were probably responsible for the reduced infiltration rate of plowed soils. This effect was particularly pronounced for the spring plow treatment, where impeded drainage resulted in both a much higher field water-holding capacity after wetting and conditions which greatly reduced soil microbial respiration. The optimum soil water status for aerobic microbial activity in soils is approximately 60% water filled pore space which was greatly exceeded in the spring plow treatment 18 hours after irrigation.

Soils must be sampled below the tillage depth to accurately assess management effects on soil quality, since considerable amounts of plant residues and SOM are

inverted during plowing. Soil analyses to a depth of 30.5 cm (12.0 in) revealed that SOM decreases due to cropping and tillage management were still present (Table 4), although less pronounced than those for surface soil. The soil quality data shown in Tables 3 and 4 were determined from different soil cores obtained using separate sampling schemes. As a result, soil quality parameters reported for the 0-7.6 cm (0-3.0 in) depth are not the same in Tables 3 and 4. Microbial C and N, mineralizable N, and extractable P in the surface 0-7.6 cm (0-3.0 in) soil layer followed similar trends observed for SOM in the following order (Table 4): undisturbed CRP  $\geq$  no-till corn  $\gg$  spring plow soybeans = fall plow soybeans.

The low levels of soil nitrate-N in the 0-30.5 cm (0-12.0 in) layer of the CRP and no-till treatments represent a marginal condition for corn production, but a good soil quality condition from the standpoint of reduced potential for N loss due to leaching or denitrification. Laboratory measurements indicated that 2.1 kg of nitrate-N/ha/day (1.9 lb/acre/day) are mineralized from the 0-30.5 cm (0-12.0 in) layer of the no-till treatment under ideal conditions of temperature and water (data not shown). This amounts to 59 kg (130 lb) of N over a 4-week period and suggests that sufficient N would be available with no-till to produce an optimal corn crop. It is interesting to note that the estimate of potentially mineralizable N in the no-till treatment (75 kg/ha/30.5 cm) (67 lb/acre/12.0 in), as determined by a one-week anaerobic incubation, also supports this conclusion (Table 4). The higher levels of nitrate-N in the moldboard plow treatments (31 to 47 kg/ha/30.5 cm) (28 to 42 lb/acre/12.0 in) suggest a lower level of soil quality because of potential for loss through leaching and denitrification and the fact that N-fixation by soybeans can be reduced by high soil nitrate-N levels. Extractable P levels for cropped soils are in the range considered medium for crop production and represent a good level of soil quality for all treatments. Final corn and soybean yields, as measured by the project coordinator, were excellent for this area (Table 5).

## Summary and conclusions

Infiltration rates on Clearfield and Nira silty clay loam soils were significantly reduced when CRP areas were returned to crop production. A substantial amount of erosion occurred from the moldboard plow treatments, but soil loss from the no-till and CRP sites was minimal. The residual

grass residue produced during the CRP period, which remained on the surface of the no-till treatments, and the better structure and organic matter content of no-till soil, proved very effective in reducing erosion. However, as the residual grass residue is lost through decomposition, additional crop residue must be provided. No-till management maintained levels of soil quality similar to those of CRP by reducing losses of SOM associated with tillage. SOM losses from plowing resulted from the combined effects of stimulated biological oxidation and increased erosion of surface soil. No-till management, by preserving SOM and surface cover, can be effective in reducing erosion potential and soil quality degradation of CRP areas returned to crop production.

## REFERENCES CITED

- Belesky, D.P., S.R. Wilkinson, R.N. Dawson, and J.E. Elsner. 1981. Forage production of a tall fescue sod intercropped with sorghum x sudangrass and rye. *Agron. J.* 73:657-660.
- Bennett, O.L., E.L. Mathias, and C.B. Sperow. 1976. Double cropping for hay and no-tillage corn production as affected by sod species with rates of atrazine and nitrogen. *Agron. J.* 68:250-254.
- Box, J.E., Jr., S.R. Wilkinson, and L.A. Harper. 1976. No-till corn production in tall fescue. p. 344-349. In J. Luchok, J.D. Cawthon, and M.J. Breslin (ed.) *Hill Lands*. West Virginia Univ. Press, Morgantown.
- Box, J.E., Jr., S.R. Wilkinson, R.N. Dawson, and J. Kozachyn. 1980. Soil water effects on no-till corn production in strip and completely killed mulches. *Agron. J.* 72:797-802.
- Carreker, J.R., S.R. Wilkinson, J.E. Box, Jr., R.N. Dawson, E.R. Beaty, H.D. Morris, and J.B. Jones, Jr. 1973. Using poultry litter, irrigation, and tall fescue for no-till corn production. *J. Environ. Qual.* 2:497-500.
- Carreker, J.R., S.R. Wilkinson, A.P. Barnett, and J.E. Box, Jr. 1977. Soil and water management systems for sloping land. ARS-S-160. U.S. Government Printing Office, Washington, D.C.
- Doran, J.W. and T.B. Parkin. 1996. Quantitative indicators of soil quality - A minimum data set. Chapter 2. In J.W. Doran and A.J. Jones (eds.), *Methods for Assessing Soil Quality*. Soil Science Soc. of Amer. spec. publ. 49, Madison, WI (in press).
- Doran, J.W., and T.B. Parkin. 1994. Defining and assessing soil quality. p. 3-21. In J.W. Doran, D.C. Coleman, D.F. Bezdicek, and B.A. Stewart (eds.), *Defining Soil Quality for a Sustainable Environment*. Soil Science Soc. of Amer. Spec. Publ. 35, Madison, WI.
- Elkins, D.M., J.W. Vandeventer, G. Kapusta, and M.R. Anderson. 1979. No-tillage maize production in chemically suppressed grass sod. *Agron. J.* 72:101-105.
- Elkins, D., D. Frederking, R. Marashi, and B. McVay. 1983. Living mulch for no-till corn and soybeans. *J. Soil Water Conserv.* 38(5):431-433.
- Foster, G.R. 1982. Modeling the erosion process. In *Hydrologic Modeling of Small Watersheds*. ASAE Monograph Number 5, Edited by C.T. Hann. American Society of Agricultural Engineers, St. Joseph, MI.
- Gebhart, D.L., H.B. Johnson, H.S. Mayeux, and H.W. Polley. 1994. The CRP increases soil organic carbon. *J. Soil Water Conserv.* 49(5):488-492.
- Giddens, J., W.E. Adams, and R.N. Dawson. 1971. Nitrogen accumulation in fescuegrass sod. *Agron. J.* 63:451-454.
- Gilley, J.E., and J.W. Doran. 1997. Tillage effects on soil erosion potential and soil quality of a former Conservation Reserve Program site. *J. Soil and Water Conserv.* 52(3) p. 184-188.
- Gilley, J.E., S.C. Finkner, R.G. Spomer, and L.N. Mielke. 1986. Runoff and erosion as affected by corn residue. Part I. Total Losses. *Transactions of the ASAE* 29(1):157-160.
- Gilley, J.E., S.C. Finkner, and G.E. Varvel. 1987. Slope length and surface residue influences on runoff and erosion. *Transactions of the ASAE* 30(1):148-152.
- Harper, L.A., S.R. Wilkinson, and J.E. Box, Jr. 1980. Row-plant spacing and broiler litter effects on intercropping corn in tall fescue. *Agron. J.* 72:5-10.
- Jones, J.N., Jr., J.E. Moody, and J.H. Lillard. 1969. Effects of tillage, no-tillage, and mulch on soil water and plant growth. *Agron. J.* 61:719-721.
- Lindstrom, M.J., T.E. Schumacher, and M.L. Blecha. 1994. Management considerations for returning CRP lands to crop production. *J. Soil Water Conserv.* 49(5):420-425.
- Lowery, B., M.A. Arshad, R. Lal, and W.H. Hickey. 1996. Soil water parameters and soil quality. Chapter 8. In J.W. Doran and A.J. Jones (eds.), *Methods for Assessing Soil Quality*. Soil Science Soc. of Amer. spec. publ. 49, Madison, WI (in press).
- Mannering, J.V., and L.D. Meyer. 1963. The effects of various rates of surface mulch on infiltration and erosion. *Soil Sci. Soc. Am. Proc.* 27:84-86.
- Moody, J.E., J.N. Jones, Jr., and J.H. Lillard. 1963. Influence of straw mulch on soil moisture, soil temperature and the growth of corn. *Soil Sci. Soc. Am. Proc.* 27:700-703.
- Parks, C.L., L.F. Welch, H.D. Morris, G.R. Craddock, G.A. Hillsman, and C.B. Elkins, Jr. 1969. Corn yields as affected by soil slope, fertilization, year from sod, and rainfall. *S.C. Agric. Exp. Stn. Tech. Bull.* 1032.
- Sarrantonio, M., J.W. Doran, M.A. Liebig, and J. Halvorson. 1996. On-farm assessment of soil quality and health. Chapter 5. In J.W. Doran and A.J. Jones (eds.), *Methods for Assessing Soil Quality*. Soil Science Soc. of Amer. spec. publ. 49, Madison, WI (in press).
- Swanson, N.P. 1965. Rotating boom rainfall simulator. *Trans. of the ASAE* 8(1):71-72.
- Wilkinson, S.R., O.J. Devine, D.P. Belesky, J.W. Dobson, Jr., and R.N. Dawson. 1987. No-tillage intercropped corn production in tall fescue sod as affected by soil control and nitrogen fertilization. *Agron. J.* 79:685-690.
- Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses—a guide to conservation planning. *Agr. Handbook* 537. U.S. Dept. Agr., Washington, D.C.
- Young, C.E., and C.T. Osborn. 1990. Costs and benefits of the Conservation Reserve Program. *J. Soil Water Conserv.* 45(3):370-373.
- Zobeck, T.M., N.A. Rolong, D.W. Fryrear, J.D. Bilbro, and B.L. Allen. 1995. Properties and productivity of recently tilled grass sod and 70-year cultivated soil. *J. Soil Water Conserv.* 50(2):210-215.